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ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

In accordance with a recent arrangement the members of the scientific staff of the Lick Observatory hold meetings once per week, as an observatory duty, to report upon and discuss the more important articles appearing in the journals of astronomy, the important new books on astronomical subjects, or subjects of current and special interest in the observatory's work. It has been suggested that abstracts of the reports would be of interest to the readers of these *Publications*, and the Publication Committee has acted favorably upon the suggestion.

It is intended to preserve the qualities of abstracts as far as possible, and to restrict published criticisms, favorable or unfavorable, to a minimum.

THE DENSE FLINT AND LIGHT FLINT PRISM.

The search for the most efficient dispersing element for the low-dispersion spectrograph of the Dominion Observatory has led Dr. PLASKETT to try different kinds of glass, as well as a grating. His report in the November-December, 1913, number of the *Journal of the Royal Astronomical Society of Canada* contains the following points: The dense flint glass *O 102* most frequently used for stellar spectrographs is somewhat yellow and strongly absorbing of violet light beyond $\lambda 4000$.

In many early-type star spectra the *K* line of calcium is the best for measurement of velocity; and in many other early-type stars in which only hydrogen lines are present greater accuracy would be gained if a greater number of hydrogen lines were available on the spectrograms. With the dense flint prism the *K* line can be obtained only by over-exposing the region between *H β* and *H γ* and losing narrow lines. Some months ago experiments with a plane grating¹ showed that, altho only 30 per cent of the light was diffracted into the first order spectrum, the spectrum was more uniform in intensity and stronger to the violet, but not much improved at the *K* line. Consequently it was not greatly advantageous to use the grating instead of the prism. Experiments by WILSING had shown the light flint transmitted more than twice as much *K* light as the dense flint. It was therefore inferred that the baryta light flint *O 722* might offer the improvement sought. A prism of baryta light flint *O 722* glass was ordered with refracting angle of 69° . When received it was mounted with

¹ *Publ. A. S. P.*, **25**, 306, Dec. 1913.

λ 4200 central. It gives star spectra very uniform in intensity from $H\beta$ to much beyond K in remarkably less exposure time. The dispersion is 55 ångströms to the millimeter, which is three fifths of the dispersion of the dense flint prism; but it could be made the same by using a camera of greater focal length. For equal dispersions the relative exposures of the light flint to the dense flint prism are found to be, for $H\beta$ λ 4861, 60 per cent, and for K λ 3933, 26 per cent. An exposure on early-type stars of half that with the dense flint prism secures six hydrogen lines beyond $H\epsilon$ of sufficient intensity to be measured, whereas $H\zeta$, the first of the six, is not measurable on spectrograms taken with the dense flint prism.

The smaller dispersion and longer camera would theoretically diminish the resolving power and definition of the spectrograph, but this would have practically no effect on most early-type spectra the lines of which are generally wide, broad, or diffuse. It is obvious, therefore, that the light flint prism has much advantage over the dense flint prism, both by increasing the extent of uniform intensity and the number of measurable lines and by diminishing the exposure time.

G. F. PADDOCK.

March, 1914.

THE WAVE-LENGTH OF X-RAYS AND ANALYSIS OF CRYSTALS.

It was recently found by LAUE that X-Rays or the heterogeneous radiation from the anti-cathode of a vacuum bulb, could be reflected by crystals and photographs made of the reflected radiation. The photographs showed a central spot surrounded by numerous smaller and fainter spots in various geometrical arrangements, depending upon the kind of crystal. The figures have been called LAUE's diffraction patterns. Subsequently W. H. BRAGG¹ of Leeds and W. L. BRAGG of Cambridge devised the X-Ray spectrometer, similar to a light spectrometer. The crystal is mounted on a rotating table. A lead block acting as a diaphragm takes the place of a collimator. An ionization chamber takes the place of a telescope or camera. With this instrument, they used homogeneous radiation from anti-cathodes of platinum, palladium and rho-

¹ *Proc. Roy. Soc. London*, **88**, **89**, 1913, 1914.

dium. They found that the reflected radiation, whose intensity is indicated by amount of ionization, is of two forms—continuous and selective. The latter consists of groups of points of increased intensity corresponding to particular angles of reflection. These points or peaks in the intensity curves are found to satisfy the formula—

$$n\lambda = 2d \sin \theta,$$

in which θ is the angle of reflection determined by the relative position of crystal and ionization chamber; d the distance between the successive planes in which molecules or atoms are arranged in a crystal, determined by means of the atomic weight and density of the crystal; λ the wave-length; n a whole number pertaining to the particular group of intensity peaks and corresponding to successive orders of diffraction spectra.

By means of this formula the wave-length λ may be determined. The form of the intensity curve and the value of λ are found to vary with the nature of the anti-cathode and to be typical of the substance. Each metal seems to have an X-Ray spectrum just as each has a light emission spectrum. The principal wave-lengths measured in tenth-meters or ångströms, which are one-ten-billionth part of a meter, have been found for a few metals. For example:—

Platinum, 1.10×10^{-10} ångströms, with rock-salt crystal.

Palladium, 0.576×10^{-10} ångströms, with diamond crystal.

Rhodium, 0.607×10^{-10} ångströms, with diamond crystal.

The X-Ray wave-length is then of the same order as the unit of light wave-length measurement—one ångström. Since the distance between atoms is of the order of 100 ångströms, so that the size of atoms is less than 100 ångströms, it is probable that their size is more or less the same as the infinitesimal magnitude of the X-Ray wave-length. This would be the case if the observed reflection of X-Rays is produced by their diffraction by the lines of atoms formed by crystallization. In fact, Professor BRAGG has concluded that the elements of crystalline structure have geometrical forms such as cubes and rhombohedrons, etc., with the atoms at their corners, in their centers, in the center of their faces, etc. The atoms

thus form in effect parallel lines in parallel planes, which act in a manner similar to the lines in the plane grating. In fact, the reflection of the X-Rays evidently takes place within the crystal and not on the crystal faces.

Professor BRAGG has arrived at these conclusions as a result of the crystal analysis made possible by the X-Rays and the spectrometer. For example, taking the crystal of rock-salt, whose molecules are composed of equal numbers of atoms of sodium and of chlorine, the analysis leads to the idea of a cube with four atoms of sodium at four corners, which are in diagonal relation to one another, and four atoms of chlorine at the other four corners which are in diagonal relation to one another. Obviously, planes formed by the opposite faces contain the same kind and numbers and arrangement of atoms; but planes cutting the cubes and their faces diagonally contain alternately only sodium and only chlorine atoms. It is found from various kinds of crystals that these different systems of planes give spectra either all alike or alternately alike, or repeating groups of varying spectra. For instance, different atoms of different atomic weight or different arrangements give different forms and different intensities in their spectra. If then a sufficient number of planes of different orientations be examined so as to give the exact spacing and relative masses of the planes or atoms, a solution of the geometrical arrangements may be obtained. Thus the atomic structure of any crystal, however complicated, may be investigated and delineated. It is found that the molecular element of the diamond is a cube with atoms of carbon at every corner and in the center of each face; that of sulphur is an oblong or orthorhombhedron with atoms of sulphur at every corner and in the centers of the end faces only; that of quartz is a hexagonal parallelopipedon with atoms at each of the twelve corners and in the centers of the hexagonal faces; that of calcite or calcium carbonate is a rhombhedron with atoms of calcium at every corner and in the center of every face; atoms of carbon at the middle point of every edge, and atoms of oxygen on certain lines joining certain carbon atoms. The latter is an example of the complexity that crystals may possess.

March, 1914.

G. F. PADDOCK.